Using the TEGAM Model 252 LCR Meter to Verify Fenwal Temperature Sensing Elements

TEGAM Model 252, is the Recommended LCR Meter for Testing Aircraft Overheat Detection Systems

Fenwal Safety Systems, a division of Kidde Aerospace, is a trusted name in the aerospace community. Today, many commercial and military aircraft companies like Boeing, Airbus, and Lockheed Martin depend on Fenwal sensors for detection of overheat conditions in specific aircraft zones such as wings, anti-ice, or bleed air ducts. A number of years ago, Fenwal Safety Systems evaluated several LCR meters and selected the TEGAM Model 252 and battery powered 252/SP2596 as their LCR, meters-of-choice, for the testing of their temperature sensing elements. This article will provide a general overview of the Fenwal sensing elements and the test methodologies used in conjunction with the TEGAM Model 252 in accurately determining the condition of the sensors. In particular the testing of the 35XXX-X-XXX continuous loop series will be discussed in detail.

General Overview of Fenwal Sensing Elements for Aircraft

Figure 1 – Fenwal Heat Sensing Elements

The Fenwal sensing element consists of a coaxial assembly, with a center conductor. Surrounding the center conductor is a eutectic salt compound embedded in a porous ceramic material. The center conductor and the compound are hermetically sealed within an outer tube.

These sensors are available with fixed temperature alarm points ranging from 180 °F (82 °C), to 900 °F (482 °C). The "melting" point of the eutectic salt compound determines the alarm point of each of these sensors. Once an element has been exposed to temperatures exceeding the alarm point, it becomes conductive creating current flow between the center conductor and the outer tubing. This increased current flow is sensed by the control unit, which annunciates the abnormal temperature condition.

The Model 252 LCR Meter

The Model 252 was originally designed by Electro Scientific Industries, ESI, as a durable, easy-to-use LCR meter intended for technicians working in production or in the field. The meter is capable of making accurate measurements of resistance, inductance, capacitance, dissipation factor or conductance. It is available as a standard 120/240 VAC @50/60 Hz powered device or may be purchased with an optional battery pack, 252/SP2596, which allows portable use in the field such as in aircraft hangars.

The 252 measures at a test frequency of 1 kHz and provides signal amplitude that will not damage Fenwal sensing elements. There are a number of test devices that produce a test signal that could produce permanent damage to temperature-sensing elements so care must be taken when selecting a test instrument for this application.

In addition to its simplicity, portability and reliability, the design of the 252 allows accurate measurement of the conductivity of the sensing element despite the large capacitive component of the sensor.

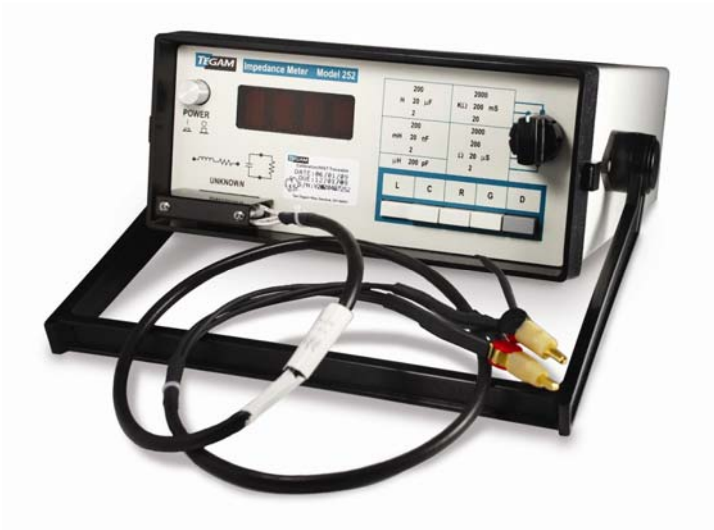

Figure 2 – The TEGAM Model 252

Optimizing Test Conditions

Before performing a conductance verification test on any of the sensing elements, it is good practice to have a general knowledge of the sensors and the precautions, which must be taken to avoid erroneous test results or serious damage to the sensor. Meggers or HiPot testers must not be used for testing these sensing elements in any way. Meters that use a DC source should also be avoided except for measuring resistance or continuity of the center conductor and then only for short durations. The sensors should not be tested if they are within 100 °F (38 °C) of the temperature alarm point of the sensor. Ideally, all temperature sensor testing should be performed with the aircraft power disabled. This will minimize the likelihood of obtaining an erroneous reading due to stray electrical interference.

Failure in taking any of these precautions could cause irreversible damage to the sensors or produce invalid test results.

With reference to the Fenwal Safety Systems Abbreviated Component Maintenance Manual for Continuous Sensing Elements, Publication Number 512, the Model 252 LCR Meter is used to measure the conductance between the center conductor and outer shell.[1] Because the sensor could be damaged by improper test voltages, special care must be taken to control the electrical test signal applied across these test points. It must be limited to 1Vrms AC and at a frequency of 1 kHz. Excessive current between these points could do permanent damage to the sensor. The Model 252 has a single test frequency and a limited output voltage, which prevents accidentally exposing the sensing element to damaging test signals.

For the conductance test, the ideal temperature of the sensing element must be kept as close to room temperature, (77 °F, 25 °C), as possible. Humidity must also be kept to a minimum as condensation could cause leakage to occur across the terminal connections. When making electrical connections to the female end of the temperature sensors, it recommended that an adapter, Fenwal P/N 06-134724-000, be used to avoid damaging the socket with the meter leads[1].

Verifying the Sensing Element

Due to the critical role that temperature sensing elements have in alerting the flight crew of an over temperature condition, efficient troubleshooting of these systems is essential to a quick return to service. A central control unit monitors all sensor loops installed throughout the airframe and engine cowls. If the controller senses a fault condition, either a short to ground or an open circuit, it outputs a maintenance alarm and a fault code. The fault code notifies the maintenance technician of the airframe zone in need of inspection. When troubleshooting overheat sensors the proper use and interpretation of test instrumentation is important in order to obtain reliable test results.

In the Fenwal CMM test procedure, the temperature sensors are categorized into two types. The first type includes all temperature sensors that have an alarm point of 310 °F, (154 °C), The second category includes temperature sensors of all other types or alarm points. Depending upon the active length and the type of sensor being tested, a high resistance, (R), or low conductivity, (G), limit can be associated with each type of sensing element. This value may be measured between the center conductor and outer tubing of the sensing element. The “Sensing Element Conductance/Resistance” table on the next page summarizes these allowable characteristics. When making a determination of the maximum allowable conductance for a temperature sensor the first step is to define the sensors active length. The active length of a sensor is found by taking the sensors overall length and subtracting the length of the two end connectors, 2 inches, from it.

SENSING ELEMENT ALARM POINT	MAXIMUM CONDUCTANCE		MINIMUM RESISTANCE	
	µs/in	µs/cm	MΩ in	MΩ cm
Type 310 °F (154 °C)	0.050	0.0197	20	50
All Other Types	0.010	0.0039	100	250

Table 1 - Sensing Element Conductance/Resistance[2]

For example, an 18”, 310 °F, sensor would have an active length of 16”. Once this active length of a sensor is determined the maximum allowable conductance or the minimum allowable resistance between the center conductor and the outer tubing may be determined. To calculate the maximum allowable conductance, the constant value in Table 1 is multiplied by the active length of the sensor.

$$\underset{Conductance\ (\mu s)}{Maximum\ Allowable} = Active\ Sensor\ Length\ (in) x\ \underset{(Constant\ from\ table\ 1)}{Conductance\ (\mu s/in)}$$

To find the maximum allowable conductance of a 310 °F sensor that is 90” long, we multiply the effective length of the sensor, 88 in. times the constant .050 µs/in. The resulting conductance limit is 4.4 µs. Thus, any sensor having a conductance greater than this value would be characterized as being a bad sensor.

LCR meters possess various design schemes, which may have an effect on their operation and how they are used to make a measurement. The 252 has a single range switch that is shared for each of the L, C, R, G, & D functions.

As typically done when measuring unknown values, it is recommended that the test leads are attached to the sensor with the meter in its highest conductance range. Then the range selection is lowered until a reading with the most significant digits is displayed.

In some instances, an over range condition, (indicated by a blank display); will be shown on the meter when measuring a conductance that is known to be within the selected range. This happens because the 252 also measures the capacitive, component of a device while reading the conductance. If the overall capacitive component of the temperature sensor exceeds the capacitance range of the meter, then an over range condition is displayed by the meter. Specifically, the capacitive component of the sensor may prevent the technician from using the absolute lowest conductance range of the meter. This is normal operation of the meter and the event is addressed by simply switching to the next higher range.

Fenwal sensors are used in virtually all military and civilian aircraft. Many aircraft manufacturers choose Fenwal sensors because of their high reliability. Regular maintenance of aircraft requires the cyclic testing of these safety systems. During these routine checks it is crucial that test practices are executed properly and that all precautionary measures are taken. This article applies specifically to the conductance measurement of Continuous Overheat Temperature Sensors and is not intended to replace

Fenwal test procedures. Its purpose is to provide supplemental information to aid in the verification of temperature sensors.

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References:

[1] Kidde Aerospace and Fenwal Safety Systems
4200 Airport Drive NW Wilson NC 27896 Tel (252) 237-7004 Fax (252) 246-7181

[2] Fenwal Safety Systems; Abbreviated Component Maintenance Manual, Continuous Sensing Elements, Series 35XXX-X-XXX. FSS Publication Number 512; 26-14-12., Feb. 12, 1996.